State of California
AIR RESOURCES BOARD

STAFF REPORT

PUBLIC HEARING TO CONSIDER AMENDMENTS TO THE 1999 SMALL OFF-ROAD ENGINE REGULATIONS

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Scheduled for Consideration: March 26, 1998
Agenda Item No.: 98- -

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I. INTRODUCTION AND BACKGROUND

A. History

The California Clean Air Act (CCAA) as codified in the Health and Safety Code (HSC) Sections 43013 and 43018 grants the ARB authority to regulate off-road mobile source categories. These categories include marine vessels, locomotives, utility engines, off-road motorcycles, and off-highway vehicles.

In December 1990, the Board approved emission control regulations for new small off-road engines. Small off-road engines include both handheld equipment (such as string trimmers and chain saws) and nonhandheld equipment (such as lawn mowers and generators).

The small off-road engine regulations include exhaust emission standards, emissions test procedures, and provisions for warranty and production compliance programs. (See Title 13, California Code of Regulations, sections 2400-2407 and the documents incorporated therein). The small off-road engine category was the first off-road category subject to emission control regulations because its emissions impact was significant and because a court order required Board action on the category by January 1991. As initially adopted, the small off-road engine regulations applied to engines produced on or after January 1, 1994. However, upon consideration of a petition filed by industry, the Board in April 1993 delayed implementation by one year; this made the regulations applicable to engines built on or after January 1, 1995. On July 5, 1995, the United States

Environmental Protection Agency (U.S. EPA) approved California's authorization request, which made the small off-road engine regulations the first enforceable California off-road emission control regulations. The adopted regulations consist of two tiers. The first tier of regulatory requirements took place in 1995, while tier 2 becomes effective in 1999.

On January 25, 1996, the ARB staff presented to the Board a status report on the industry's progress towards meeting the Tier 2 (1999) regulatory requirements. The Board directed the staff to perform additional outreach and analysis of the small off-road engine manufacturers' capability of complying with the 1999 Tier 2 standards.

B. Recent Events

The ARB staff has met with various entities regarding the small off-road engine regulations since the January 1996 Board meeting. The staff held general public workshops on May 22, 1996, and May 6-7, 1997; the staff held a workshop specifically to discuss the emissions inventory on December 16, 1997. The staff also met with engine manufacturers, trade associations, emission control manufacturers and developers, and other interested parties in numerous individual meetings.

Additionally, the U.S. EPA worked with much of industry and other interested parties in a regulatory negotiation to develop a small engine regulation for the rest of the nation. The participants did agree that a program virtually identical to the ARB Tier 1 program was appropriate for Phase 1 of the federal program, but failed to reach a consensus with regards to a more stringent Phase 2 program. However, much of the work done in the regulatory negotiation was used as a basis for agreements between the U.S. EPA and much of industry regarding Phase 2. The agreements, referred to as Statements of Principles, listed specific provisions that the U.S. EPA would propose. The Statements of Principles were signed by much, but not all, of the small off-road engine industry.

The staff has used the information from its own efforts and from the regulatory negotiation to evaluate the industry's ability to meet the 1999 standards. The staff's proposal provides a significant relaxation, in lead time and stringency of the adopted standards, for both handheld and nonhandheld equipment. However, the handheld and nonhandheld portions of the industry have not progressed equally. Specifically, in the case of handheld equipment, the staff concluded that several manufacturers had independently developed strategies to comply

with the 1999 standards, and that the manufacturers of handheld equipment primarily needed a small amount of additional lead time, and flexibility in compliance. Thus, the staff proposes to delay the implementation of the Tier 2 standards by one year while retaining the emission standard for smog forming hydrocarbons (HC) and oxides of nitrogen (NOx). Relaxations of the particulate matter (PM) and carbon monoxide (CO) standards, and procedural changes to reduce compliance costs, are also proposed. Additionally, the staff proposes alignment with U.S. EPA programs where possible.

In the case of nonhandheld equipment, industry 's research efforts indicated that the 1999 standards would be difficult to achieve in the time allotted. Furthermore, new industry test data indicated that engine deterioration resulting in increased emissions deterioration had been underestimated in the original rulemaking efforts. As a result of this new information staff is proposing to revise the emission standards to reflect and, as a result, reduce in-use emission deterioration, relax the emission standards to reflect the slower than anticipated development of cleaner technologies, and provide one additional year of lead time for compliance. As with handheld equipment, the staff proposes alignment with U.S. EPA programs where possible.

Finally, the staff has revised the emissions inventory for small off-road engines to incorporate updated information on population, usage, and emission rates including in-use emission deterioration. The result is that the emissions inventory from small off-road engines approximately doubles compared to estimates made in 1990.

The regulatory text of the staff proposal is contained in Attachment A, whereas the emissions test procedures are contained in Attachment B. The proposed revisions are intended to achieve significant emissions reductions beyond the Tier 1 levels while providing industry with greater flexibility than the existing regulations. The effect of the revised regulatory changes and the improved emissions inventory on the State Implementation Plan obligations is discussed in detail in Section IV of this report.

II. SUMMARY OF ARB STAFF PROPOSAL

Staff's meetings with manufacturers have indicated that some changes to the existing regulations are necessary; the staff therefore recommends that the small off-road engine regulations be modified to reflect the current technological capabilities of the industry. Additionally, staff has identified ways to provide industry with greater flexibility in compliance while maintaining

the goal of reducing emissions. The proposed modifications are described briefly below, and are presented in more detail in Part III, Discussion.

A. Applicability

The small off-road engine requirements currently apply to engines below 25 hp, with the exceptions of off-road recreational and specialty vehicles and marine propulsion engines. However, specialty vehicles below 25 hp are currently required to meet the same emissions standards as other small off-road engines. To simplify matters, the staff proposes to revise the regulations to include all engines less than 25 hp that are used in mobile applications, with the more specific exceptions of off-road motorcycles, all-terrain vehicles and engines used to propel marine vessels or watercraft. New golf carts for use in areas that do not meet the federal ozone standards will continue to have a zero-emission requirement.

The regulations would continue to exclude construction and farm equipment engines, consistent with the 1990 Clean Air Act Amendments' preemption of state authority, and the U.S. EPA's subsequent implementation of that provision. Attachment C has a list of preempted equipment.

B. Handheld/Nonhandheld Distinction

The current small off-road engine regulations contain two major categories: "handheld," which includes products such as chain saws, trimmers and leaf blowers; and "nonhandheld," which includes products such as lawn mowers, edgers, pumps, and generators. In many cases, however, the introduction of very small, portable products has blurred this distinction. The staff therefore proposes to remove the distinction between handheld and nonhandheld equipment. Instead, staff proposes to base emissions standards solely on engine displacement; engines 60 cubic centimeters (cc) and below would be subject to emissions standards consistent with the capabilities of a clean handheld engine, while engines above 60 cc would be subject to emissions standards consistent with the capabilities of a clean nonhandheld engine.

C. 0-60 cc ("Handheld")Emissions Standards

The staff proposes to extend the Tier 1 standards through 1999, and institute new emissions standards with the 2000 model year, a one year delay. The adopted Tier 2 emissions standards for handheld engines are presented below, as are the proposed

standards for comparison. The staff notes that the proposal represents a relaxation of the adopted Tier 2 standards. The adopted Tier 2 standards represent an 80 percent reduction from uncontrolled HC+NOx levels in 2010, whereas the proposal would be a 74 percent reduction from uncontrolled levels in 2010. The proposed combination of HC plus NOx and less stringent CO and PM standards provide industry and consumers with greater flexibility regarding the technology for compliance. All emissions standards are presented in units of grams per brake horsepower-hour (g/bhp-hr).

Table 1

Adopted & Proposed
0-60 cc Emissions Standards

Year	Standards g/bhp-hr		
	HC+NOx	CO	PM
1999 Adopted	50 HC, 4.0 NOx	130	0.25
2000 Proposed	54	400	1.5

D. Greater Than 60 cc ("Nonhandheld")Emissions Standards

The staff proposes to extend the Tier 1 standards through 1999, and institute new Tier 2 emissions standards with the 2000 model year, a one year delay. The staff also proposes Tier 3 standards which would go into effect in 2004. The adopted Tier 2 emissions standards for nonhandheld engines are presented below, as are the proposed standards for comparison.

Table 2

Adopted & Proposed
Greater than 60 cc Emissions Standards

Year	Engine Class[1]	Displacement	Standards g/bhp-hr	
			HC+NOx	CO
1999 Adopted	1 & 2	all	3.2	100
2000 Proposed	1	< 225 cc	12.0	410
	2	$\geq$ 225 cc	9.0	410
2004 Proposed	1	< 225 cc	9.0	410
	2	$\geq$ 225 cc	7.0	410

The proposed Tier 2 standards appear to be 3 to 4 times less stringent than the current standards. However, the new standards would require manufacturers to demonstrate the durability of their emissions controls, because testing showed that in-use emissions from these engines could be quite high. The result will be lower in-use emissions over the life of the engines than the original standards would achieve. The proposed Tier 3 standards reflect the addition of low-cost, low-efficiency catalysts to the Tier 2 engines.

Overall, the staff proposal for engines greater than 60 cc displacement represents a relaxation of the adopted standards. The adopted 1999 standards represent a 92 percent reduction from uncontrolled HC+NOx levels in 2010, whereas the proposal would be a 67 percent reduction from uncontrolled levels in 2010.

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[1]Engine class is based on the displacement of the engines. Class 1 refers to engines less than 225 cc; Class 2 refers to engines equal to or greater than 225 cc. Walk-behind lawn mowers for residential use would typically use Class 1 engines.

E. Compression-Ignition Engines

The staff proposes to implement the Compression-Ignition Engine Statement of Principles agreed upon by ARB, the U.S. EPA, and various members of the industry. The standards will be implemented throughout the nation and are shown below.

Table 3

Compression Ignition Engine Standards
ARB/U.S. EPA/Industry Agreement

Year	Horsepower	Emissions Standards g/bhp-hr		
		NMHC+NOx	CO	PM
2000	<11	7.8	6.0	0.75
	≥11-<25	7.1	4.9	0.6
2005	<11	5.6	6.0	0.6
	≥11-<25	5.6	4.9	0.6

F. Emissions Durability

The staff proposes to revise the regulations to ensure that engines are "emissions durable," i.e., controlled throughout their useful lives, by requiring that manufacturers conduct a durability demonstration as part of the certification process. The staff proposes to differentiate engines based on an emissions durability period, similar to the methodology used by the U.S. EPA for small nonroad engines. Manufacturers would choose an emissions durability period for each engine family from the periods shown in Table 4, below.

Table 4

Emissions Durability Periods

Engine Size	Durability Periods (hours)		
0-60 cc	50	300	
Above 60 cc	125	250	500

Manufacturers would be required to note the durability period on the engine label, on the equipment label, on the equipment box, and in the owner's manual.

G. Averaging, Banking, and Trading

The staff proposes to allow corporate averaging to show compliance with the HC+NOx standard. For each engine family, a manufacturer would determine the Family Emission Limit; the Family Emission Limit would serve as the "emissions standard" for compliance purposes. Individual Family Emission Limits could be above the standard, provided the average of all a manufacturer's Family Emission Limits (weighted by power, load factor, sales and durability period) met the standard. Averaging would be carried out by an emission reduction credits mechanism. The proposed credit program is similar to that proposed by the U.S. EPA for small nonroad engines. It is designed to provide industry the flexibility to deal efficiently with problems such as low sales volume engines which would be particularly costly to control; averaging would allow manufacturers to focus their efforts on the higher sales volume families first.

H. Production-Line Testing

The staff proposes that the current quality audit requirements be modified to allow manufacturers to follow a procedure similar to the U.S. EPA's Cumulative Sum procedure. The Cumulative Sum procedure replicates the statistics of a federal compliance program known as a "Selective Enforcement Audit," while providing greater opportunity for a quick decision, thus reducing the manufacturer's possible testing burden, particularly for those engine families that consistently meet the standards by a wide margin. The minimum number of tests required is only two, the

maximum thirty, as compared to the current program 's requirement that one percent of all engines be tested.

The staff has modified the Cumulative Sum procedure to ensure year-round sampling, but otherwise the program remains much the same as the proposed federal program.

I. Production Emission Reduction Credits

A manufacturer would generate Production Emission Reduction Credits when the final HC+NOx sample mean (from production line testing) of an engine family is below the Family Emission Limit. In this way, manufacturers will receive consideration of the "headroom" or compliance margin that they have designed into their engines. The staff proposes that production emission reduction credits, being based on actual production engines, could be used for certification and as a remedy for noncompliance of another engine family; this would introduce another degree of flexibility which does not exist in the current program.

J. Small Volume Manufacturers

The staff proposes to provide relief to manufacturers that produce less than 500 engines annually for California by simplifying the certification requirements.

K. Emissions Warranty Parts List

Staff also proposes to modify the list of emissions-related parts covered by the emissions warranty to include air filters and pressure regulators.

L. Other Miscellaneous Modifications

The staff also proposes to make other miscellaneous modifications to the regulations and test procedures to clarify or simplify existing language.

III. DISCUSSION OF RECOMMENDED ACTION

The following discussion of the staff's proposal has been divided into five sections: a section regarding the general applicability of the regulations, a section regarding spark-ignition engines 60 cc displacement and below (handheld), a section regarding spark-ignition engines above 60 cc displacement (nonhandheld), a section relevant to CI engines, and a section

concerning the other compliance and manufacturer flexibility options that the staff is proposing.

A. General

1. *Applicability* - The staff proposes to revise the regulations to include all engines less than 25 hp that are used in mobile applications, including specialty vehicle and golf cart engines below 25 hp. Specialty vehicle engines are currently regulated under the off-highway recreational vehicle sections of Title 13, California Code of Regulations, although they are required to meet the same standards as the engines in this category. The engines are substantially similar to other engines covered by the small off-road engine regulations. Staff believes that the consolidation of the category will improve the administration, implementation and enforcement of the regulations.

Similarly, the staff proposes that the regulations will explicitly apply to golf carts. New golf carts that will be used in areas that meet the federal ozone standards will be required to use certified engines. New golf carts for use in areas that do not meet the federal ozone standards will continue to be subject to a zero-emission requirement.

The 1990 Clean Air Act Amendments preempt state authority to establish emissions standards for new construction and farm equipment below 175 hp. Thus, engines that meet the federal definitions of construction or farm equipment are not subject to the existing standards, and would not be subject to this proposal. There are a number of equipment types less than 25 hp that have been determined to meet those definitions. These include, but are not limited to, compressors, chain saws 45 cc and greater, tractors, welders, pumps 40 cc and greater, and stump beaters. As noted previously, Attachment C has a complete list of preempted equipment.

The staff also proposes to specifically exclude engines used to propel marine vessels from this category. Staff plans to propose separate regulations for those vessels which will address their unique operating characteristics.

Additionally, the staff proposes to further modify the applicability of the regulations to remove the provision that includes engines that produce a rated power greater than 25 hp but are governed to produce less than 25 hp. That provision has caught some engines in a regulation that may be inappropriate. For instance, it includes some engines that are built on an

automotive base. Although most engines of that type would normally be greater than 25 hp, and thus be included in an upcoming regulation for engines greater than 25 hp, some applications involve governing the engine to a level that produces less than 25 hp. The result can be that the engine manufacturer designs the engine in good faith expecting that it would not be subject to the small off-road engine regulations, but that the manufacturer's customer installs an engine speed governor that reduces the usable power below 25 hp and places the engine under these regulations. Since the engines will be regulated under an upcoming rulemaking to levels appropriate to their automotive origins, the staff believes that it is appropriate to exclude them from the requirements of the small off-road engine category. The emissions effect of the proposed change should be negligible, as there are relatively few engines that would fall under this provision, and they will ultimately be regulated.

2. *Handheld/Nonhandheld Distinction* - The small off-road engine regulations currently draw a distinction between handheld equipment applications (e.g., chain saws) and nonhandheld equipment applications (e.g., lawn mowers). The historical reason for this division was to ensure that multi-positional equipment supported solely by the operator would be able to continue to use two-stroke engines, despite their higher emissions, while other equipment would have to use lower emitting four-stroke engines. Two-stroke engines, although intrinsically about ten times more polluting than four-stroke engines, are lightweight in comparison to the power they generate, and can be used in any position.

Although the distinction largely succeeded in allowing handheld applications to use lighter, multi-positional engines, the staff and industry encountered a number of difficulties with the definitions. There was some initial disagreement, for instance, as to whether an edger with one guide wheel qualified as being "fully supported by the operator," and thus should be allowed to use engines that could meet the handheld standards, but not the nonhandheld standards. Staff and industry agree that setting an engine standard based on the equipment application has been somewhat clumsy, and has complicated the certification process.

Upon review of certification data for non-preempted engines, the staff has determined that there is a natural break between engines used in most handheld applications and engines used in

most nonhandheld applications at about 60 cc [2]. Below that level, high-speed, lightweight engines, such as two-stroke engines or small "handheld" four-stroke engines, like those offered by Ryobi and Honda, are most desirable. Above that level, lower-speed engines which are typically larger and heavier relative to their power output are more appropriate. A displacement-based standard would allow an engine manufacturer to have a single fixed emissions target from the start of engine design. It would also allow the ARB staff to more efficiently carry out certification and inspection of engines in the category, by eliminating the need to track down end-use applications, which sometimes may be far downstream of the actual engine manufacturer. Finally, the staff believes that placing the division at 60 cc would provide greater flexibility while avoiding the proliferation of dirtier engines in traditionally nonhandheld equipment such as lawn mowers. The staff believes that these reasons support the deletion of the handheld/nonhandheld distinction and its replacement with a distinction between engines 60 cc and below and engines above 60 cc.

B. 0-60 cc ("Handheld") Engines

1. *Technology* - Some equipment types have traditionally used two-stroke engines because of the need for light weight and multi-positional operation. As noted previously, the initial regulation distinguished between handheld and nonhandheld applications, and allowed continued use of higher-emitting two-stroke engines for handheld equipment. Staff proposes to continue this distinction which will allow some engines to emit at higher levels in return for lighter weight and multi-positional use, but base the distinction on factors intrinsic to the engine rather than the application.

The existing Tier 2 standards that would apply to handheld engines (50 g/bhp-hr HC, 4.0 g/bhp-hr NOx, 130 g/bhp-hr CO, 0.25 g/bhp-hr PM) were based on the assumption that manufacturers would comply by installing 60-70 percent efficient catalysts on Tier 1 two-stroke engines. Recent data show that catalyst efficiency has not reached this level, at least in this time frame. However, other alternatives, such as modifications to the basic two-stroke engine or replacing it with a lightweight, high output four-stroke engine, have been developed and

[2]Although commercial-type chain saws may have displacements greater than 60 cc, chain saws greater than 45 cc are preempted, and would not be affected by this proposal.

commercialized. PPEMA has suggested that California should adopt the U.S. EPA Phase 2 standards, which are emissions durability-based standards designed to be 30 percent lower than the current Tier 1/Phase 1 new engine standards. However, the U.S. EPA Phase 2 standards will not achieve the emissions reductions that California needs from handheld equipment to comply with the SIP. Table 5 compares the U.S. EPA proposal to the ARB's adopted standards and the staff's proposal. The staff's proposed HC+NOx standards are about four times less stringent than the standards proposed for larger engines; this distinction is made in recognition of the unique characteristics of these engines.

Table 5

Adopted & Proposed
0-60 cc Emissions Standards

Year	Standards g/bhp-hr		
	HC+NOx	CO	PM
ARB 1999 Adopted	50 HC, 4.0 NOx	130	0.25
U.S. EPA 2002-2005 Proposed [3]	128	600	N/A
ARB 2000 Proposed	54	400	1.5

As mentioned above, several alternatives to the originally envisioned two-stroke engine/catalyst compliance strategy have appeared. Various manufacturers have indicated that they can meet the standards with small four-stroke engines, two-strokes with direct fuel injection, or two-strokes with stratified scavenging. Details on the current status of these technologies

[3]The proposed U.S. EPA standard s shown are for engines 20-50 cc, which comprise the overwhelming majority of certified engines 60 cc or below in California. The proposed U.S. EPA standards would be phased-in beginning in 2002, with full implementation by 2005.

are provided below; more background detail was presented to the Board in January, 1996 (see Attachment D).

a. Four-Stroke Engines - Four-stroke engines possess the advantage that the exhaust stroke does not expel much entering unburnt fuel, so engine-out HC emissions are much lower than a two-stroke engine. This is because exhausting the spent gases and refilling the cylinder with a fresh air/fuel charge happens simultaneously in a two-stroke engine, but sequentially in a four-stroke engine. In the past, four-stroke engines have not been able to operate multi-positionally, due to lubrication problems, so four-strokes have not traditionally been used in handheld equipment. The adoption of the 1999 standards, however, caused manufacturers to reexamine the use of four-stroke engines in handheld equipment. Although four-stroke engines were not a consideration in developing the Tier 2 standards in 1990, the technology has progressed to the point where it is a likely power source for most handheld equipment.

Ryobi, for instance, has developed a multi-positional handheld four-stroke engine that can meet the adopted standards. Ryobi has publicly stated that the 1999 standards should be retained without change. A trimmer with Ryobi's engine has been on the market since 1994. The original trimmer Ryobi offered was in a relatively high-end product, a common practice for the introduction of new technology. Consumer surveys have indicated that users have found it acceptable, and Ryobi has indicated that it plans to expand the application of its engine to lower-cost products. Ryobi representatives have also stated that they plan to introduce more models in the next two years, ranging from 26 cc to 60 cc, to provide engines that can fill the entire less than 60 cc displacement range in both commercial and residential products. The new designs are expected to improve on the original model.

In April of 1995, Ryobi announced that it was willing to license its four-stroke technology to other companies to assist them in meeting the regulations. Ryobi has indicated that it is currently having discussions with a number of manufacturers regarding the production of four-stroke engines for those manufacturers. Further, although Ryobi is a high-volume manufacturer of residential garden equipment, it has also entered into a partnership with Komatsu Zenoah to produce a four-stroke engine appropriate for commercial use later this year. Komatsu Zenoah markets equipment under the RedMax name.

Honda has also developed handheld four-stroke engines that can meet the 1999 standards. Honda has already certified 22 cc and

31 cc engines, and has indicated that it will make handheld engines in other displacements as well. Honda has extensive experience with high-output, lightweight four-stroke engines, primarily due to its motorcycle production. Honda has indicated that it intends to use its engine in trimmers, blowers, and edgers. Honda had not previously offered handheld equipment, but evidently sees the regulations as providing an opportunity to use its expertise to enter a new market. Honda has been producing its trimmer since 1997.

Honda also sells to other equipment manufacturers. For 1998, Maruyama is introducing two commercial trimmers that utilize Honda four-stroke engines. Maruyama provided information to *Power Equipment Trade* that notes that some advantages of the four-stroke engine are no mixing of gas and oil, higher torque at low engine speed, and ease of starting. Maruyama also said that "a typical commercial operator could easily save $200 in fuel and 2-stroke oil costs through the first year of operation." [4]

b. Fuel-Injected Two-Stroke - Fuel injection provides better control of the amount and the timing of fuel entering the cylinder. By limiting the fuel admitted to the amount necessary for combustion, and timing fuel introduction to limit the fuel exiting with the exhaust gases, less unburnt fuel exits the engine. The loss of unburnt fuel is the primary cause of the high HC emissions from two-stroke engines; nearly one third of the fuel going into a conventional two-stroke engine exits the exhaust pipe unburned.

The use of fuel-injection to improve the emissions performance of two-stroke engines has been investigated by several companies. Stihl, a prominent German manufacturer, has developed a fuel-injected unit that achieved levels of 23.7 g/bhp-hr HC+NOx when tested on a 71 cc chain saw engine. However, Stihl has indicated that the cost increase associated with fuel-injected equipment would be prohibitive (approximately a $200 increase in retail price)[5]. Given that the Stihl fuel injection system produces emission levels which are approximately one-half the proposed standard, the staff believes that it may be possible for Stihl to reduce the cost, at the expense of a modest emissions increase

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[4] *Power Equipment Trade*, December 1997

[5] "Presentation for the CARB - W orkshop May 23, 1996, Exhaust emission control systems and fuel systems", May 16, 1996.

which would still enable the system to meet the proposed standard.

Other companies have been even more successful with fuel-injection technologies. The ARB's Innovative Clean Air Technology (ICAT) program enabled a consortium of interested parties, including BKM, a research firm, and the handheld equipment manufacturer, Tanaka, to develop a fuel injection design that can attain the 1999 standards. Tanaka believes that the system is economically viable, and has asked the staff to maintain the 1999 standards. Early tests of the prototype unit produced HC+NOx emissions results of 23.6 g/bhp-hr [6].

c. Stratified Scavenging Two-Stroke - Komatsu Zenoah, in addition to working with Ryobi to develop a commercial version of the Ryobi handheld four-stroke engine, found another way to meet the 1999 standards. Komatsu Zenoah developed an engine that uses an air bleed to reduce scavenging losses. The system works by injecting a "barrier" of air to separate the incoming fuel from the expended charge that is being exhausted. The result is that less of the fresh (unburnt) fuel escapes, and HC emissions are dramatically reduced. Test results of the Komatsu Zenoah engine indicate that the technology can easily meet the Tier 2 standard [7]. Komatsu Zenoah plans to start production of a California-certified engine with stratified scavenging by the 2000 model year (see Attachment E). The Komatsu Zenoah engine is particularly noteworthy because it retains all the advantages of a conventional two-stroke: lightweight, high power output, relatively simple design, and hence high potential for low-cost versions. The fundamental improvements to two-stroke engines developed by Komatsu Zenoah result in an engine which operates nearer to the chemically balanced air/fuel ratio (rather than introducing large amounts of excess fuel), which translates into a very large improvement in efficiency which is reflected in improved fuel economy.

d. Two-Strokes with Catalysts - In addition to the above technologies, the staff believes that catalyst-equipped two-stroke engines still show promise with regards to meeting the

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[6]"Report, Fuel Systems Subgroup of the Technology Task Group, to the Regulatory negotiation Committee for Small Spark-Ignited Engines < 19 kW phase 2 Rulemaking", September 20, 1995.

[7]Society of Automotive Engineers Paper No. 972114, "A Study on Advanced Low Exhaust Emission Two-Stroke Engine" by Sawada, Wada, Noguchi, and Kobayashi, October 1997.

Tier 2 HC+NOx standard. Husqvarna has certified three "E-Tech" engine families which involve some internal engine modifications, as well as the use of a catalytic converter. Husqvarna announced the catalyst technology in July 1996, stating that it could achieve a level 40 percent below the Tier 1 standard (108 g/bhp-hr HC is 40 percent below the Tier 1 standard of 180 g/bhp-hr) when new, and that it had the potential to achieve emissions levels 60 percent below the Tier 1 standards (72 g/bhp-hr). The actual certification levels at a lean/lean setting are very close to the 54 g/bhp-hr standard; this shows significant promise.

It remains to be seen how the system works over the useful life of an engine. The industry is convinced that the emissions of a two-stroke engine will not deteriorate with time. Thus, the only deterioration expected would occur in the catalyst. Husqvarna has not supplied staff with any data regarding the E-Tech's catalyst deterioration, but staff discussions with the Manufacturers of Emissions Controls Association have indicated that deterioration is expected to be minimal. With further development, catalyst-equipped two-stroke engines may play a significant role in the category.

The E-Tech engines are currently on the market, with little or no increase in price from Husqvarna's earlier products. Husqvarna has not shared any information regarding future marketing plans, but staff notes that the Poulan/Weedeater brands of products are owned by the same parent company, Electrolux. Presumably, the E-Tech technology could be shared among all Electrolux brands.

Additionally, other manufacturers currently offer equipment with catalytic converters in Europe, where use of catalytic converters has succeeded economically and with respect to customer acceptance. In fact, the presence of a catalyst is sometimes used as a marketing feature in Europe.

e. Electric Equipment - Another option, at least for residential applications, is the use of electric equipment. Electric equipment tends to be less expensive than the equivalent gasoline-powered equipment, with comparable performance on residential products. Staff investigated the products available at several mass market stores, and found a variety of corded electric equipment, including blowers, chain saws, trimmers, and hedge trimmers. Staff also found battery-powered trimmers and hedge trimmers.

Staff does not believe that electric equipment could serve as readily in commercial uses, which typically require greater mobility than afforded by corded equipment and greater length of operation than provided by battery-powered units.

The importance of electric equipment to the analysis is primarily that it will remain available as a consumer choice when gasoline products experience modest price increases to offset the cost of emissions controls. Market shifts to electric equipment would produce additional emissions benefits. Most manufacturers do offer electric equipment now, and expansion of their electric product lines is an option they may choose.

f. Summary of Technical Options - Table 6, below, contains the latest emissions results from the technologies described above, as compared with the EPA SOP standard level for class 4 engines (20-50 cc), and the staff proposal. There are numerous technical options for compliance with the staff proposal.

Table 6

0-60 cc ("Handheld") Engine Emissions Capabilities

Description	HC+NOx Level (g/bhp-hr)	Engine Size	Comments
U.S. EPA SOP	128	20-50 cc	128 g/bhp-hr is deteriorated level.
Husqvarna E-Tech	49.6 (new)	36 cc	Catalyst-equipped two-stroke at lean setting. Manufacturer concerned about operability at lean setting at certain operations.
Husqvarna E-Tech	49.9 (new)	31 cc	"
Husqvarna E-Tech	55.9 (new)	25 cc	"
Ryobi Four-stroke	48.8 (new)	26 cc	Manufacturer has indicated that the engine can be calibrated leaner. Minimal deterioration expected.
Honda Four-Stroke	15.5 (new)	31 cc	Some deterioration expected, but expected to meet 54 g/bhp-hr HC+NOx over useful life.
Honda Four-Stroke	17.1 (new)	22 cc	"
ICAT BKM/Tanaka Fuel-Injected Two-stroke	23.6	66 cc	Breadboard system in U.S. EPA tests. BKM/Tanaka almost ready for pre-production.
Komatsu Zenoah Stratified Scavenging Two-stroke	32.5 (new)	34 cc	Minimal deterioration expected.
Staff Proposal	54	0-60 cc	Deteriorated level

2. *Carbon Monoxide and Particulate Matter Standards*

a. Carbon Monoxide - Many manufacturers have indicated that the existing Tier 2 CO standards would prove an

impediment to control of HC and NOx. Specifically, industry has argued that the high level of CO reduction needed would require an oxidation catalyst, and that the heat generated by the CO conversion would become another problem for engine designers to address. They further contend that if the regulation did not require extensive CO reduction, technologies other than oxidizing catalysts could be applied. For example, a reducing catalyst would be effective in decreasing HC+NOx emissions at a more reasonable temperature, and would not have much effect on CO emissions.

Despite the above technical arguments for relaxing the CO standards, the staff has received some comments from parties opposing relaxation, because significant concerns about the health effects of CO remain. There are still some counties in California working to attain the ambient CO standards, although most counties have reached attainment. Given the above, the staff proposes to relax the existing 1999 standard, but cap CO emissions from handheld equipment. The proposed cap of 400 g/bhp-hr is more stringent than the Tier 1 standard of 600 g/bhp-hr, but should not be so stringent that it becomes the primary concern when engine manufacturers choose control strategies for their products. Virtually all engines currently certified meet this level.

b. Particulate Matter - The existing 1999 standards include a PM standard of 0.25 g/bhp-hr. During development of the SOP for handheld equipment, PPEMA presented information that suggests that PM emissions from two-stroke gasoline engines are unlikely to pose the same risk to public health as diesel PM. PPEMA has argued that whereas diesel PM is primarily carbonaceous material, PM from two-stroke gasoline engines is primarily composed of hydrocarbons from unburnt oil. PPEMA has also contended that measures to reduce exhaust hydrocarbons would also result in a reduction of PM emissions and that there is therefore no need for a separate PM standard.

Staff has carefully considered PPEMA’s arguments and agrees that measures to reduce HC would also reduce two-stroke PM. Further, attaining the ambient particulate standards in California remains a daunting challenge which will require every possible control measure. The ARB and the air pollution control districts with the most severe problems have developed plans to reach attainment, but will need to develop new plans to comply with the upcoming revised federal particulate standards. Any action to relax standards that have already been approved must be carefully

considered in that light. Staff does not, therefore, believe that it is appropriate to propose the deletion of the PM standard.

However, the staff believes that, as with CO, a relaxed standard is appropriate at this time. Furthermore, because the sampling equipment required for PM is extremely expensive, the staff proposes that compliance with the proposed PM standard be determined through an engineering evaluation process, rather than through direct measurement. PPEMA has provided information that indicates that PM emissions from two-stroke engines will be no greater than the HC emissions from the engine divided by the fuel to oil ratio used in the engine. For example, if a two-stroke engine has HC emissions of 50 g/bhp-hr, and a fuel to oil ratio of 40 to 1, the PM emissions would be expected to be no greater than 50/40 or 1.25 g/bhp-hr. In fact, sample data indicate that the actual PM emissions would be below that upper bound. Thus, adoption of this method of compliance determination should provide compliance with the standards equivalent to full testing, while limiting the burden on industry.

Industry has noted also that the 0.25 g/bhp-hr level amounts to much more stringent reduction of PM than of any other pollutant. The existing Tier 2 PM standard was based on the assumption that the primary compliance technique would be the use of catalyst-equipped two-stroke engines, which will probably not be the case. Staff believes that the conjunction of these circumstances make a re-evaluation of the PM standard appropriate.

Staff has examined numerous industry submissions to determine a PM level that achieves percentage reductions of a magnitude similar to the reductions accomplished by the tier 2 HC standard. The information indicates that a PM standard of 1.5 g/bhp-hr would be consistent with the HC emissions associated with the Tier 2 standards.

3. *Lead Time* - Since technologies are available that meet the proposed standards, the staff does not believe that there is a technical need to extend the lead time prior to implementation. However, because the regulations would change from a calendar year basis to a model year basis, and from new engine standards to emissions durability standards, staff believes that some extension of lead time is warranted. Therefore, it proposes that for engines less than or equal to 60 cc in displacement (handheld), industry be granted a one-year extension of lead time prior to the initial implementation.

Thus, the staff proposes to continue the current (Tier 1) standards through 1999; the proposed standards would begin with the 2000 model year. To reward those manufacturers who have managed to meet the standards prior to 2000, the staff proposes to award credits for 1998 and 1999 production, as detailed in section III A (4). The staff's proposed handheld engine emissions standards are summarized in Table 2.

4. *Test Cycle* - The current handheld test cycle consists of 2 modes: a full power mode, weighted at 90 percent, and an idle mode weighted at 10 percent. Work recently performed as part of the U.S. EPA/industry regulatory negotiation effort indicates that the test cycle could be made more representative of actual operation by changing the modal weighting so the full power mode was weighted at 85 percent, and the idle mode weighted at 15 percent. The U.S. EPA has proposed to make the change as part of its Phase 2 rulemaking, and has support from much of industry, including PPEMA. The staff proposes to harmonize with U.S. EPA on this issue by modifying the test cycle used for engines less than or equal to 60 cc in displacement.

C. Greater than 60 cc ("Nonhandheld") Spark-Ignition Engines

1. *Technology* - The existing Tier 2 standards for nonhandheld engines require a 3.2 g/bhp-hr HC+NOx level in 1999. That level was developed in 1990 from the assumption that manufacturers would be able to use 60-70% efficient catalysts on Tier 1 overhead-valve engines. Although significant work has been done to approach those efficiency levels, staff does not believe that the 3.2 level is achievable by most of the engines in the category. Furthermore, the existing Tier 2 standards do not address the issue of emissions deterioration. Investigations conducted since 1990 have indicated that emissions deterioration from these engines can be quite significant. Therefore, the staff proposes to relax the level of the existing standards, but to also include provisions to control emissions deterioration. To provide time for industry to make a technological shift, the standards would consist of two stages. The proposed Tier 2 standards would essentially require an early implementation of the federal Phase 2 standard for Class 2 engines, which will require manufacturers to control emissions durability at existing emissions levels. Similarly, the proposed Tier 2 standards for Class 1 engines will require manufacturers to control emissions durability at existing levels. The proposed Tier 3 standards are based on the use of catalysts on the Tier 2 engines, but the

efficiency of the catalysts is assumed to be lower than originally estimated in 1990.

The available information, including information provided by the Engine Manufacturers Association (EMA), indicates that Class 1 (less than 225 cc) side-valve engines in general deteriorate much more than Class 2 (greater than 225 cc) side-valve engines or overhead-valve engines of either class. Although the staff takes no position regarding how a manufacturer meets the emissions standards, deterioration of emissions performance is a concern. Accordingly, the staff disagrees with the approach taken in the federal Statement of Principles which includes standards that allow for the continued use of Class 1 engines with high deterioration. As staff noted in 1990 and subsequently, it believes that standards based on the emissions capabilities of 1990-type side-valve engines would be insufficient for California's public health and air quality needs. Instead, staff continues to take the position that the Tier 2 standards should be based on the capabilities of the more efficient and durable engines -- i.e., new Class 1 engines (whether side-valve or overhead-valve) should initially be no dirtier than the current Class 1 overhead-valve engine average certification values, and that over the durability period the new Class 1 engines should possess emissions durability equivalent to that achievable by an overhead-valve engine.

The virtues of overhead-valve engines are widely recognized. One mass-market retailer has touted the advantages in its advertising literature, noting that overhead-valve engines run cooler, use less fuel, are quieter, and have up to 40 percent longer life. Thus, the staff believes its proposal would provide ancillary benefits to consumers in addition to the emissions reduction.

Staff does expect that some manufacturers will, for market reasons, wish to continue to produce side-valve engine models. Certainly, manufacturers would be able to market any side-valve engine that complies with the standards, either directly or through averaging. It should also be noted that side-valve engines capable of meeting the proposed standards would almost certainly provide the same benefits as overhead-valve engines noted above, particularly with respect to fuel consumption and durability. The standards remain performance-based; manufacturers will be able to use any technology that accomplishes the ultimate goals.

Although some engines are currently capable of meeting the existing 3.2 g/bhp-hr HC+NOx standard when new (see Table 6 for a list of currently certified engine families that meet or approach the 3.2 standard), those engines are suitable for only a limited number of applications, and are much more expensive than the typical engine. Typically, the engines that approach the 3.2 g/bhp-hr HC+NOx standard are Liquefied Petroleum Gas (LPG) engines equipped with three-way catalysts and closed-loop fuel control which is similar to automotive technology, although there are some gasoline engines that have attained equivalent levels. These listed engines are intended primarily for use indoors, and must meet other safety- and health-based requirements that the typical engine in this category does not. Additionally, the listed engines are overwhelmingly used by businesses rather than homeowners. Thus staff does not believe that the engines shown in Table 7 represent the technical and economic capabilities of all engines below 25 hp.

As noted above, the existing regulations do not limit the emissions deterioration of the engines. Therefore, the staff has attempted to strike a balance that partially offsets the relaxation of the emissions requirements by limiting emissions deterioration. The staff believes that this will achieve significant emissions reductions while maintaining overall equipment availability. In fact, the shift in emphasis from control of new engine levels to control of emissions deterioration through the proposed standards described below, would provide benefits beyond those expected from the existing 1999 standards.

Table 7

Currently Certified Engine Families
That Meet or Approach the 3.2 g/bhp-hr HC+NOx Standard

Make	Engine Family	HC+NOx	Power (hp)	Applications
Daehung	TDE180U1G1EA (Gasoline)	4.2	5.0	Generator, Rotary Tiller, Hydraulic Pump
Flex Systems	TFX570U1L2EA (LPG)	2.4	2.0	Floor Buffer, Polisher
Generac	TGN216U1L1RB (LPG)	4.5	8.3	Generator
Kohler	SKH398U1L2EC (LPG)	4.0	11.1	Floor Buffer, lawn mower, Utility
Westerbeke	VX7660U5G2EA (Gasoline)	1.7	13.3	Generator
Wiscon	SWP883U1G2EA (Gasoline)	2.2	18.0	Pump, Mixer

2. *Standards* - The existing 1999 standards were set in 1990 based on the application of a 60-70 percent efficient catalytic converter to overhead-valve engines, but did not control deterioration; the proposed federal standards are not based on the introduction of catalysts, but do establish limits on deterioration. The staff's proposal would accomplish both goals: in the near-term it would require manufacturers to control deterioration by switching to overhead-valve engines or durable side-valve engines, and in the mid-term it would promote the use of catalytic converters on those improved engines. Table 8 contains a comparison of the four sets of standards.

Table 8

Adopted & Proposed
Greater than 60 cc Emissions Standards

Year	Standards g/bhp-hr (Class 1/Class 2)		Deterioration Control	Requires Catalyst
	HC+NOx	CO		
ARB 1999 Adopted	3.2	100	No	Yes
U.S. EPA 2001-2005 Proposed	18.7/9.0	455	Yes	No
ARB 2000 Proposed	12.0/9.0	400	Yes	No
ARB 2004 Proposed	9.0/7.0	400	Yes	Yes

a. HC+NOx - Staff determined the levels at which to set the emissions standards by the methodology described below. Essentially, the proposed Tier 2 standards are based on the use of the lower emitting subgroup of federal Phase 2 engines, and the proposed Tier 3 standards are based on the use of a Tier 2 engine with a low-efficiency catalyst. Any discrepancies are due to rounding the figures to one significant decimal place.

i. Proposed Tier 2 Standards

Class 1 - The proposed federal Class 1 standard would not provide sufficient pollution control for California’s air quality needs. However, the staff does believe that the Memoranda of Understanding negotiated outside the federal rulemaking by the U.S. EPA and some engine manufacturers contain some promising goals. The memoranda require the two largest engine

manufacturers, Briggs & Stratton and Tecumseh, to develop the capacity to produce overhead-valve engines for Class 1 applications. The anticipated result is that Class 1 engines would feature cleaner and more durable technology than they would otherwise. The staff developed a Class 1 standard that it believes is consistent with the stated goals of those memoranda. The average of the current Class 1 overhead-valve certification levels is 8.7 g/bhp-hr. Multiplying by a 1.3 deterioration factor (DF), appropriate for the technology involved, produced an end-of-life (250 hours) level of 11.3 g/bhp-hr. The staff realizes that attaining a DF of 1.3 may be a challenge for some engine models in this category, most of which are relatively inexpensive. Therefore, staff also added a small compliance margin to yield a standard of 12.0 g/bhp-hr. Thus, this proposed standard would essentially modify the existing Tier 1 standard from a new engine standard to an emissions durability-based standard.

The following table has a partial list of some of the currently certified engine families that could comply with the proposed Tier 2 standards if they have a DF of 1.3 over the emissions durability period. All the engines listed are gasoline engines certified for California production in 1996. All were brought into compliance with the Tier 1 regulations by relatively simple engine modifications.

Table 9

Class 1 Engines
Expected to meet the Proposed Tier 2 emissions standards

Make	Engine Family	Expected deteriorated HC+NOx (If DF=1.3)	Power (hp)	Applications
Briggs & Stratton	SBS182U1G1RA	9.1	4.7	General Utility, Generators
Briggs & Stratton	TBS190U1G1RA	11.3	3.3	Walk Behind Lawn Mower
Generac	SGN216U1G1RA	9.6	6.6	Generator
Honda	THN196U1G1RA	8.7	6.5	Lawn Mower, Generator, Tiller
Kawasaki	SKA153U1G1RA	11.5	4.0	Walk Behind Lawn Mower
Onan	SN5197U1G1RA	10.3	5.8	Generator
Tecumseh	TTP195U1G1RA	9.0	5.5	Tiller, Generator

Class 2 - Determining the class 2 standard was simpler, because they are based on the federal Phase 2 levels which staff agrees are appropriate. The staff's proposed Tier 2 standards would encourage the early introduction of federal Phase 2 engines, at 9.0 g/bhp-hr HC+NOx. If the methodology for deriving the Class 1 engine standard is used here for the Class 2 engines, the derived standard is consistent with the proposed level; the application of a 1.3 DF to the average Class 2 overhead-valve certification level of 6.8 g/bhp-hr provides a result of 8.8 g/bhp-hr.

The staff proposes that the Tier 2 standards be implemented in the 2000 model year. Some delay is warranted by the change to emissions durability standards, but the delay should be minimal, because the new standards are a relaxation of the present Tier 2 standards scheduled for 1999. The proposed standards and other associated requirements would also be more in harmony with the U.S. EPA Phase 2 programs than the current standards would be. Staff believes that a number of currently certified engines would be capable of meeting the proposed 2000 standards; the engine

families listed in Table 10 and others that could have been included comprise 31 percent of the annual Class 2 sales. Furthermore, the 2000 implementation would allow industry to use California as a proving ground for the impending federal requirements and allow a slow increase in production of Tier 2/Phase 2 engines.

Table 10

Class 2 Engines
Expected to meet the Proposed Tier 2 emissions standards

Make	Engine Family	Expected deteriorated HC+NOx (If DF=1.3)	Power (hp)	Applications
Briggs & Stratton	SBS465U1G2RB	7.1	12.2	Lawn Tractor
Briggs & Stratton	SBS297U1G2RA	8.7	7.0	Generator, General Utility
Honda	THN635U1G2RA	8.1	20.0	Lawn Tractor, Lawn Mower, General Equipment
Kohler	SKH398U1G2RB	7.8	14.0	Lawn Tractor, Pressure Washer
Onan	SN5390U1G2RA	7.7	14.0	Lawn Mower, Welder, Pressure Washer, Generator
Tecumseh	TTP358U1G2RA	7.2	13.5	Lawn Tractor

In general, fuel control is an important step in the control of emissions from small off-road engines. Improved fuel control will lower HC emissions while improving fuel economy, and will make the addition of a low-efficiency catalyst easier, if needed. There are a number of ways to improve fuel control, including carburetor redesign and fuel injection, both of which can be relatively costly in comparison to the cost of these engines. There are also other techniques that may prove more appropriate for these engines. For example, the Lean Power Corporation, has successfully applied electronic air/fuel mixture control to engines in this category, including Briggs & Stratton side-valve and overhead-valve engines and a Honda overhead-valve engine. In

all cases, the Lean Power device reduced HC emissions by allowing the engines to operate at a relatively lean, but stable condition.

The Lean Power device essentially leans the engine out until it detects any instability. At that point, the device corrects the mixture with slight enrichment. The device can detect instability well before the person using the engine, so the user would not notice any difference between an engine equipped with the device and an engine without the device. Under transient conditions and starting, the device reverts to the default carburetor setting. Similarly, when a load is applied to the engine, enrichment occurs to compensate. The result is a well-performing engine that continually runs as lean as feasible, greatly reducing HC emissions. Furthermore, the Lean Power device or something that imposed similar control of the air/fuel mixture could help catalyst operation, by providing a consistent mixture and moderating the extreme lean and rich operation that the engine might otherwise experience.

ii. Proposed Tier 3 Standards

For the Tier 3 standards, staff assumed the use of a catalyst that would reduce HC+NOx by 25 percent at the end of useful life. For Class 1 engines, the Tier 3 standard would require a catalyst that could convert 3.0 g/bhp-hr HC+NOx at the end of useful life. That results in a Tier 3 standard of 9.0 g/bhp-hr.

For Class 2 engines, staff assumed the use of a catalyst at the same end of useful life efficiency noted above. At the end of useful life, the engine-out emissions from a Class 2 engine would be 9.0 g/bhp-hr. Thus, at the end of useful life, the catalyst would need to reduce 2.3 g/bhp-hr HC+NOx (25 percent reduced). Staff then added a small compliance margin to the resulting value of 6.8 g/bhp-hr to determine the proposed 7.0 g/bhp-hr standard.

Staff proposes to implement the catalyst-based standards in the 2004 model year, which would provide industry a four-year period of stability between Tier 2 and Tier 3. Note that even the proposed Tier 3 standards are a relaxation of both the emissions levels and the timing of the existing 1999 standards, but this was necessary to require manufacturers to meet durability-based standards.

Although there are many types of equipment with catalytic converters offered today (primarily in Europe), including tillers and lawn mowers, some manufacturers have expressed concerns about the use of catalytic converters on this equipment. The concerns include deactivation by operation with the manual choke on or poisoning from lubricating oil; efficiency limitations due to packaging concerns; heat management, the engine/equipment packaging, and the cost (see Attachment F). Essentially, those concerns have all been addressed by the staff's proposed relaxation.

Deactivation by operation with the choke on is primarily a problem with oxidation catalysts with air injection or aspiration. The extra fuel introduced by choking then combusts in the catalyst, causing damage through catalyst overheating. The low-efficiency catalysts envisioned by the staff proposal will not require air injection and should be resistant to choke on operation. It is also possible to link the choke to an engine's throttle linkage so that the choke is automatically disengaged when the throttle is advanced for the engine to accept a load.

Deactivation from lubricating oil contamination is primarily related to engine oil passing the engine's piston rings and valve guides and entering the exhaust stream. Additives in the oil then coat the catalyst, reducing its activity. The extent of the problem depends upon overall oil consumption. One of the major contributors to oil consumption is cylinder bore distortion when the engine is hot. This problem is more severe with side-valve engines than with overhead-valve engines because a side-valve's exhaust port is adjacent to the cylinder and difficult to cool. The industry trend to overhead-valve engines is the obvious solution to oil consumption problems. Other approaches include tighter manufacturing tolerances and the use of seals which limit the oil available to the valve guides.

Efficiency limitation due to packaging constraints have been addressed by the staff's use of a low-efficiency (25 percent) assumption for the proposed Tier 3 standards. This allows the use of small catalysts which can usually be packaged in the engine's muffler. Automotive catalysts are larger relative to engine size and are more than 99 percent efficient.

The catalysts being called for would also be relatively inexpensive. The Manufacturers of Emissions Controls Association has indicated that most catalysts of this nature could be

supplied to the engine manufacturers for $4.35 to $10.67 per unit in small volumes, and $2.91 to $7.17 per unit if the marketplace was somewhat larger, and the effects of economies of scale and increased competition could take effect. More details on the costs are included in the Cost-Effectiveness Section.

Finally, staff wishes to emphasize that the catalysts it has examined would not be the expensive, limited-volume systems that currently exist for floor polishers and other equipment intended for indoor use. As noted previously, staff agrees that those systems, which must reduce CO by a very large amount, would be inappropriate for most of the engines and equipment under discussion. The staff is proposing the introduction of smaller, less expensive catalysts that would not be required to meet the demands asked of catalysts for indoor equipment.

b. Carbon Monoxide - As with the CO emissions from the 0-60 cc equipment, and for much the same reasons, the staff proposes that CO levels be capped at the 1996 standard level (350 g/bhp-hr when new). Because the 1996 standard is a new engine standard, staff has applied the U.S. EPA's CO DF of 1.17 and determined that the equally stringent emissions durability level would be 410 g/bhp-hr at the end of useful life.

3. *Lead Time* - Most of the arguments for extra lead time have been touched on above. Since the proposed standards are in some ways a relaxation of the existing tier 2 standards, little lead time should be required prior to implementation. However, the staff recognizes that the change in regulations from a new engine standard to an emissions durability standard should be accompanied with an additional year of lead time for manufacturers to adjust. Therefore, the staff proposes to retain the current (Tier 1) standards through 1999, and implement the proposed Tier 2 standards beginning in 2000, and the proposed Tier 3 standards in 2004 (see Table 2).

The proposal overall is a relaxation of the 1999 standard for new nonhandheld engines, in return for a greater assurance of control of emissions throughout the engine’s useful life.

D. Compression-Ignition Engines

The staff proposes that the current (Tier 1) standards for compression-ignition engines be retained until 2000, at which time the compression-ignition Statement of Principles that ARB,

U.S. EPA and various industry members have agreed upon would take effect. The CI SOP standards would be a relaxation of the existing 1999 standards; however, the staff does not believe that a 3.2 g/bhp-hr HC+NOx standard is attainable in the prescribed time period. Moreover, the CI SOP will provide benefits sufficient to achieve the ARB's M9 & M10 SIP measures, while providing California/Federal harmonization of the regulations and the assurance of control over preempted farm and construction equipment engines. The SOP standard levels for HC+NOx, CO and PM are shown in Table 3.

The staff is proposing regulatory language that is consistent with the language proposed by U.S. EPA in its Notice of Proposed Rulemaking in late 1997. The staff notes that the final language to implement the compression-ignition engine SOP has not yet been approved; if the final federal program is substantially different, the staff will return to the Board to propose further alignment of the two programs.

E. Other Aspects of the Staff Proposal

1. *Emissions Durability* - As mentioned above in the standards discussion, the adopted 1999 small off-road engine regulations require that engines meet the emissions standards only when new, allowing the deterioration of emissions performance to proceed unchecked. When the regulations were adopted in 1990, industry and staff believed that small off-road engines did not appreciably deteriorate. This belief was based on information gathered primarily from uncontrolled engines running at very rich settings. Subsequent information, including that generated during the U.S. EPA's regulatory negotiation with industry, has shown that such an assumption does not necessarily hold for controlled engines. Therefore, the staff proposes to revise the regulations to ensure that engines are "emissions durable," i.e., controlled throughout their useful life. To accomplish this, staff proposes that certification testing be done similarly to the current durability protocol followed for automobile certification.

a. Emissions Durability Period - The staff proposes to differentiate engines based on expected useful life. Manufacturers would be able to choose between three emissions durability periods for engines greater than 60 cc; manufacturers of engines 60 cc and below would be able to choose from two emissions durability periods (the emissions durability periods are similar to those detailed in the handheld equipment Statement

of Principles agreed upon by industry and U.S. EPA). The staff believes that market forces would encourage manufacturers to choose appropriate useful life periods for their engines. The emissions durability periods would apply to spark-ignition engines only; compression-ignition engines would be subject to the useful-life and compliance periods detailed in the U.S. EPA regulatory proposal developed to implement the Compression-Ignition Statement of Principles (Attachment G). The emissions durability periods are detailed in Table 11.

Table 11

Emissions Durability Periods

Engine Size	Durability Periods (hours)		
0-60 cc	50	300	
Above 60 cc	125	250	500

Although the emissions compliance would be based on a given durability period, the standards would not differ from one durability period to another. A manufacturer that chose the 500-hour durability period for marketing reasons would have to meet the standard at 500 hours, while one that chose the 125-hour durability period would have to meet the same level at the shorter number of hours.

A virtue of the emission durability period is that it provides consumers with a greater amount of information on which to base a purchase. Therefore, the staff proposes that manufacturers be required to note the durability period on the engine label, on the equipment label, on the equipment box, and in the owner's manual. The staff believes that this will result in products that have emissions durability commensurate with their mechanical durability, as consumers make informed decisions regarding their purchases.

b. Deterioration Factors - Staff proposes to use a deterioration factor (DF) to represent the deterioration expected of an engine at the end of its emissions durability period. To establish a DF the manufacturer would test one engine at zero hours, at the middle of the durability period and at the end of the durability period. The manufacturer would be allowed, but not required, to test at additional points at equal intervals

between zero hours and the end of the durability period. The manufacturer may also choose to replicate tests for greater certainty. The manufacturer would fit a line to those points, and determine the DF by calculating the value for the end of the emissions durability period and dividing that value by the value at zero hours. The DF would be multiplied by the zero-hour emissions whenever an engine was tested for compliance purposes, alleviating the need to perform costly engine aging on each engine tested under new engine compliance or production line testing.

2. *Averaging, Banking and Trading of Credits* - Staff proposes to allow manufacturers to demonstrate certification compliance to the HC+NOx standards based on the weighted corporate average emissions. The weighted corporate average emissions would be determined by the emissions durability levels, weighted by sales, power, load factor, and useful life. Overall, the staff believes that the averaging, banking and trading program would enable a manufacturer to develop an emissions control strategy tailored to the specifics of that manufacturer's design and production practices. This would allow a manufacturer to utilize its resources in the most economically efficient way, and should result in lower costs. For example, a manufacturer could target one engine line for large reductions because that engine can be cheaply controlled, and could forego expensive development work on low-volume products that might otherwise be discontinued. A detailed description of the mechanics of the averaging plan is contained in Attachment H.

Alternatively, a manufacturer could choose simply to certify its engine families directly to the emissions standards, as is currently done. This approach would require less record-keeping on the part of the manufacturer.

To reward those manufacturers who have been able to comply with the existing Tier 2 standards, the staff proposes to allow the early generation and banking of credits for 0-60 cc engine families that are certified to or below 54 g/bhp-hr HC+NOx in 1998 and 1999, and for engine families above 60 cc that are certified to or below 3.2 g/bhp-hr HC+NOx. (These levels are equivalent to the original 1999 standards, with the exception that HC and NOx have been combined for consistency with the rest of the proposed credit program.)

3. *Production Line Testing* - The staff proposes that the current quality audit requirements be modified to allow

manufacturers to follow a procedure similar to the U.S. EPA's Cumulative Sum procedure. The Cumulative Sum procedure replicates the statistical foundation of the federal Selective Enforcement Audit, while providing greater opportunity for a quick decision. Thus, the Cumulative Sum procedure would reduce the manufacturer's possible testing burden, particularly for those engine families that consistently meet the standards by a wide margin.

The staff proposes the adoption of a modified Cumulative Sum procedure to ensure year-round sampling; otherwise the program remains much the same as the proposed federal program. Staff opted to retain year-round sampling because of its experience with the current quality-audit test program. Staff has noted that some engine families that have demonstrated good performance in the first or second quarters of production may then encounter serious difficulties complying in later quarters. Testing at least two engines per production quarter, should ensure compliance throughout the model year. Despite this modification, the total number of tests that manufacturers will be required to conduct will be less than the present program. The maximum number of tests per engine family per year under the proposal would be thirty, but the program offers the prospect of concluding testing earlier if the results are consistent and below the standard; this should be compared to the current quality-audit program which requires testing one percent of production, which could be over 1000 engines for the larger engine families. Overall, staff believes that the Cumulative Sum procedure will reduce the testing burden on manufacturers, and provide greater consistency with the U.S. EPA. A complete description of the Cumulative Sum program and the staff's proposed modifications may be found in Attachment I.

4. *Additional Manufacturer Flexibility* - Staff proposes the following additional programs to provide industry with greater flexibility in complying with the regulations.

a. Small Volume Manufacturers - The staff recognizes that small volume manufacturers may require special consideration to continue to serve their niche markets. To ensure continued product availability, the staff proposes to provide an assigned DF to manufacturers that produce less than 500 engines annually for California. This will eliminate the need to conduct durability testing and reduce the number of engines that must be used in the certification process.

b. Production Line Testing - The staff proposes a means by which manufacturers can remedy their production line testing and new engine compliance failures by use of credits (see section 5, above). The staff's proposal would make the availability of emissions reductions credits a factor when the question of remedial or punitive action is considered. Additionally, the staff proposes to grant the Executive Officer the authority to administratively suspend or revoke certification, as the Executive Officer may do with automobiles and other sources. These provisions will allow quicker and more appropriate resolutions to incidents of noncompliance than the current provisions, which allow only enjoinment of sales as a corrective measure.

5. *Emissions Warranty Parts List* - Staff also proposes to modify the list of emissions-related parts covered by the emissions warranty. Specifically, the staff proposes to include air filters under the Air Induction System portion of the list. In recognition of the use of alternatively fueled engines, the staff also proposes to add pressure regulators to the items included as part of the fuel metering system.

6. *Other Miscellaneous Modifications* - The staff also proposes to make other miscellaneous modifications to the regulations and test procedures. These changes would clarify or simplify existing language and reduce duplication of language in the regulations and test procedures.

IV. AIR QUALITY, ENVIRONMENTAL AND ECONOMIC IMPACTS

A. Air Quality and Environmental Impacts

1. *Impacts on the 1994 Ozone SIP and Inventory* - The 1994 State Implementation plan (SIP) for Ozone is California's master plan for achieving the federal ozone standard in all areas of the state by 2010. The 1994 Ozone SIP includes state measures to control motor vehicles and pesticides, local measures for stationary and area sources, and federal measures for sources under exclusive or practical federal control. The 1994 Ozone SIP was approved by the U.S. EPA in September 1996. Although the U.S. EPA has not yet approved subsequent plan revisions for ozone, carbon monoxide, and particulate matter, these plans also rely on measures in the 1994 Ozone SIP.

Because the small off-road engine regulations were already adopted at the time the 1994 Ozone SIP was developed, emission reductions from those regulations were incorporated into the SIP baseline. Regulations in the baseline for the 1994 Ozone SIP were also carried over into the subsequent plans.

a. Inventory - Since 1994, substantial improvements have been made to the emissions inventory for small off-road engines. Updated data on activity, growth, population, emission rates (including emissions deterioration), and which engine applications are exclusively under the jurisdiction of the U.S. EPA (i.e., are preempted), have been incorporated into the revised inventory. The result is that the HC+NOx emissions from the population of uncontrolled engines triples to over 200 tons per day by 2010. Both handheld and nonhandheld inventories increase. Much of this increase results from new testing which has shown that these engines experience deterioration as they age, resulting in increased emissions over time. At the time of the regulation (1990) and SIP (1994) adoption, emission deterioration was not thought to occur.

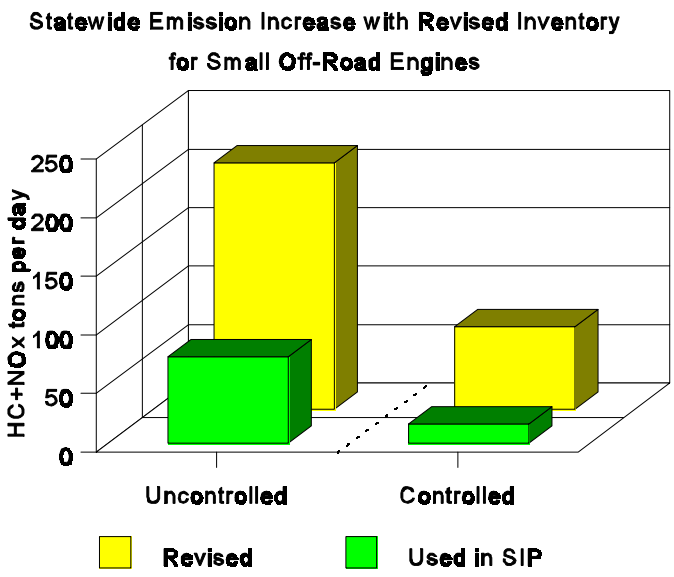

Figure 1 illustrates the impact of the revised estimates of small off-road engine emissions, both for uncontrolled engines and for engines which meet the adopted emission standards.

Figure 1

b. Review of 1999 ARB Standards - Many of the ARB's mobile source measures require new technologies to be developed or existing technology to be applied in new ways. Lead time is provided to ensure that industry has time to incorporate these technological changes. For regulations that require future phase-in of significant new standards, equipment, or processes, the ARB staff must periodically evaluate the technological, economic, and market feasibility of the regulations prior to implementation.

After evaluating the adopted Tier 2 standards for small off-road engines, staff has determined that relaxing the emission standards and providing a one-year delay in implementation is necessary to reflect the technical capabilities of the industry, and the lead time needed for compliance. The proposed one-year delay will allow industry time to prepare for the proposed addition of an emissions durability demonstration.

c. Assessing the Impacts of the Proposal on the SIP - Attainment of the national ozone ambient air quality standard is premised on reducing emissions to a specified level within an urban area. The maximum allowable emissions level is called the carrying capacity. Attainment of the federal ambient air quality standards requires that the carrying capacity not be exceeded. The 1994 SIP established this level for each non-attainment area, and the Board approved the emission reduction measures needed to achieve this level. Based on the adopted regulations, the target for small off-road engines is 16.5 tons per day HC+NOx on a statewide basis. this value remains the target today.

However, the emission target for these engines will not be met, for the following reasons: 1) The emissions from small off-road engines are much greater than was believed in 1994, 2) the

proposed relaxation of the standards, 3) the additional lead time provided for implementation, and 4) the preemption of engines which need only meet more lenient federal standards. Table 12 below illustrates that emissions in 2010 will be over 50 tons per day greater than the emission target.

Table 12

Emissions Will Exceed SIP Target
HC+NOx (tons per day in 2010 statewide)

Category	Emissions		Further Reductions Needed
	Target based on SIP	Resulting from Staff Proposal *	
0-60 cc (handheld)	11.9	24.8	12.9
> 60 cc (nonhandheld)	4.6	45.0	40.4
Total	16.5	69.8	53.3

* Reflects the U.S. EPA proposed standards for preempt engines.

d. Finding the Additional Reductions Needed - The staff has identified fuel spillage during refueling as a source of HC emissions from small off-road engines. Fuel spillage is expected to contribute approximately 10 to 15 tons per day of HC statewide in 2010. Members of industry, including EMA and the Outdoor Power Equipment Institute, have indicated a willingness to work with staff to develop an appropriate rule and to quantify the results of refueling control. Staff will work with industry and other stakeholders, and return to the Board with a proposal in 1999. At this time, it is anticipated that a fuel spillage control measure could be implemented in the 2001 to 2002 time frame. Staff will also seek other sources of emission reductions.

e. Alternatives - Industry has argued that ARB should adopt the proposed U.S. EPA second phase of emission standards for small off-road engines. Table 13 illustrates the impact of such action. As can be seen, HC+NOx emissions would be more than 20 tons per day higher in 2010, compared to the staff proposal, and this would further increase the reductions needed to meet the SIP target.

Table 13

Comparison of ARB Proposal to Federal Standards
for Nonpreempted Engines
HC+NOx (tons per day in 2010 statewide)

Category	Controlled Emissions		Benefit of ARB Proposal over U.S. EPA Standards
	w/U.S. EPA Proposed Standards	w/ARB Proposed Standards	
0-60 cc (handheld)	35.4	20.6	14.8
> 60 cc (nonhandheld)	36.1	27.1	9.0
Total	71.5	47.7	23.8

2. *Carbon Monoxide* - Attainment of the federal and state ambient standards for CO is expected by year 2000. Although the staff proposal will result in an increase in CO emissions compared to the adopted 1999 ARB small off-road engine standards, the increase is small (about 250 tons per day statewide in 2010), and will not affect attainment.

3. *Particulate Matter* - The effect of the proposal on the statewide PM inventory is shown in Table 14, below. Compared to the adopted 1999 ARB standards, the staff proposal is expected to result in 0.4 more tons per day of PM in 2010.

Table 14
Comparison of ARB Proposal to Existing PM Standards
(tons per day in 2010 statewide)

Engine Type	Adopted ARB Regulations	Proposed ARB Regulations	Benefit
0-60 cc	0.6	0.8	-0.2
>60 cc	1.2	1.4	-0.2
Total	1.8	2.2	-0.4

4. *Proposed Federal Standards* - The U.S. EPA has not yet adopted second phase emission standards for small off-road engines; it has recently published a Notice of Proposed Rulemaking. The proposed rule is designed to implement the Statements of Principles reached with much of the industry. The emission limits contained in those agreements are less stringent than those proposed by the ARB staff. The U.S. EPA's actions impact California's clean air plans because ARB is preempted from controlling emissions from small off-road engines principally used in farm and construction equipment. Thus, only U.S. EPA can address emissions from this sector. As shown in Table 15, the proposed U.S. EPA standards would increase HC+NOx emissions by 6.0 tons per day beyond the standards reflected in the SIP.

Table 15

Impact of Proposed Federal Standards on Preempted Engines
HC+NOx (tons per day in 2010 statewide)

Category	Controlled Emissions		Shortfall
	If Met Existing 1999 ARB Standards	If Met Proposed U.S. EPA Standards	
0-60 cc (handheld)	3.5	4.2	0.7
> 60 cc (nonhandheld)	12.7	18.0	5.3
Total	16.2	22.2	6.0

B. Economic Impacts

In the May 1996 and May 1997 workshops, and in Mail Out # 97-15, dated August 1, 1997, the staff requested that industry provide specific cost information so that the economic impact of regulations could be determined. Although the responses specific to the questionnaire were limited, other sources of information were made available; for example, the Engine Manufacturers Association (EMA) provided cost information through a contractor, the National Economic Research Associates (NERA). Staff evaluated the responses, along with cost information from its contractors, the Manufacturers of Emissions Controls Association, and other companies when calculating the following costs.

For all cost-effectiveness figures, the staff has attempted to estimate the increase in retail price due to emissions controls beyond those required for the federal program. Those costs were then compared to the emissions reductions the proposal would achieve beyond those achieved by the federal program.

1. *0-60 cc ("Handheld") Engines* - For smaller engines, typically used in handheld equipment, the staff calculated the cost effectiveness of engines that would meet the 2000 standard.

Engine, Fuel, and Emissions Engineering, prepared a report (see Attachment J) in which it estimated the increase in retail price for a variety of approaches. Table 16 contains the results for the technologies staff expects to be used to comply with the proposal. The fuel injection estimate used information from a prior report, with the same dealer markup assumed in the later report.

Table 16

Technologies for 0-60 cc Engines
Retail Price Increase

Technology	Increase due to engine cost	Increase due to equipment cost	Total Retail Price Increase
Four-stroke engines	$19.68	$ 0.73 (trimmer/chain saw) $ 0.34 (blower)	$20.02-$20.41
Two-stroke with stratified scavenging	$ 4.66	$ 0.00	$ 4.66
Two-stroke with catalyst (ceramic substrate)	$ 8.30	$ 2.80	$11.10
Two-stroke with catalyst (metallic substrate)	$13.66	$ 2.80	$16.46
Two-stroke with fuel injection	$35.55	$ 0.00	$35.55

To prevent an underestimation of the costs, staff has calculated all cost-effectiveness using the highest retail price increase in the table, $35.55. The cost-effectiveness depends on the equipment evaluated, but the staff has determined the cost effectiveness for the following representative types of equipment.

Blowers: Calculation of the lifetime emissions from a blower indicates that a blower engine in the less than 2 hp range meeting the federal Phase 2 standards would produce a total of 61.1 pounds of HC+NOx over the average life of the engine. Similarly, a blower engine meeting the staff proposal would emit a total of 10.4 pounds of HC+NOx over the average life of the engine. Therefore, the cost effectiveness for the staff's Tier 2

proposal for blowers would be calculated as follows (discrepancies are due to rounding):

Federal SOP lifetime emissions = 61.1 pounds HC+NOx
Staff Proposal Tier 2 lifetime emissions = 10.4 pounds HC+NOx
Difference = 50.7 pounds HC+NOx

Cost Effectiveness = $35.55/50.7 = $0.70 per pound HC+NOx reduced.

Trimmers: Federal SOP lifetime emissions = 32.9 pounds HC+NOx
Staff Proposal Tier 2 lifetime emissions = 5.6 pounds HC+NOx
Difference = 27.3 pounds HC+NOx

Cost Effectiveness = $35.55/27.3 = $1.30 per pound HC+NOx reduced.

Chain Saws: Federal SOP lifetime emissions = 98.6 pounds HC+NOx
Staff Proposal Tier 2 lifetime emissions = 25.1 pounds HC+NOx
Difference = 73.5 pounds HC+NOx

Cost Effectiveness = $35.55/73.5 = $0.48 per pound HC+NOx reduced.

Additionally, because there are several four-stroke engines certified already, staff has used the above methodology to estimate the cost-effectiveness for the same applications using four-stroke engines.

Blowers: $20.41 /50.7 = $0.40 per pound HC+NOx reduced.
Trimmers: $20.41/27.3 = $0.75 per pound HC+NOx reduced.
Chain Saws: $20.41/73.5 = $0.28 per pound HC+NOx reduced.

All other equipment should fall within the range of $0.28-$1.30 pound/HC+NOx reduced. Taking into account the improvement in fuel economy that will occur from any of the technologies identified above (except for catalyst technology), the cost effectiveness improves for residential use, and becomes a net savings for commercial users. Engine, Fuel and Emissions Engineering estimates the fuel consumption for a complying engine of this type to be approximately 0.95 pounds per horsepower-hour; the Tier 1 fuel consumption is approximately 1.18 pounds per

horsepower-hour. The result is fuel cost savings over Tier 1 of approximately $3.50 for a piece of residential equipment, and about $89 for a commercial unit. Thus, a commercial user would experience an operating cost savings from using Tier 2 equipment compared with Tier 1 engines. Similarly, compared to an engine meeting the federal proposal, residential users would save $0.60 in fuel, and commercial users $15.35.

These cost-effectiveness estimates do not include any benefit due to a shift from gasoline-powered equipment to electric equipment. The staff believes that some shift may occur, particularly for the lower-priced entry-level consumer equipment. Such a shift would favorably alter the cost-effectiveness of the regulations by increasing the benefits from the proposal; if the price of electric equipment stays below the cost of engine-powered equipment, as would be expected, the cost-effectiveness could be improved even further.

The estimate of four-stroke engines increasing the retail price by approximately $20 per piece of handheld equipment derived by Engine, Fuels, and Emissions Engineering is substantiated by data from those companies that have produced handheld four-stroke engines and equipment for sale. However, other manufacturers have expressed doubt that this figure is accurate and have noted that current four-stroke trimmers on the market sell for more than $20 beyond the lowest-priced two-stroke trimmers. As mentioned above, the current four-stroke equipment on the market represents the introduction of a new product, and has tended to be on equipment above the entry-level price. It is also currently produced in relatively low volumes. The currently available four-stroke models include features lacking from the lowest-priced trimmers. A four-stroke trimmer without the extra features would be much lower priced. Ryobi has stated that it believes four-stroke trimmers could be sold for $100 in high volume without the extra features currently offered. Additionally, the other compliance strategies are expected to have very little impact on the retail price. Husqvarna reportedly sells its E-Tech for the same price as the previous models without catalytic converters or the other E-Tech modifications.

Averaging will allow manufacturers an opportunity to modify their product mix in such a way as to minimize market disruptions. If some of the market switches to electric, as staff foresees, the average cost per unit of equipment should drop below the $20 per engine that is used in the cost calculations, because electric

equipment tends to retail for significantly less than engine-powered equipment. Because the increased demand is likely to slightly increase the prices and alter the product mix of electric equipment, the staff cannot quantify the effects of a switch to electrics at this time.

2. *Greater than 60 cc ("Nonhandheld") Spark-Ignition Engines*

a. Tier 2 Cost of Compliance - The proposed standard for Class 1 engines which are greater than 60 cc, but less than 225 cc, will probably cause manufacturers to shift production from side-valve engines to overhead-valve engines. This shift is consistent with the memoranda of understanding that the two largest-volume engine manufacturers, Tecumseh and Briggs & Stratton, signed with the U.S. EPA. Those memoranda outlined an agreement for those companies to develop the capacity to produce a substantial number of overhead-valve engines below 225 cc. The memoranda do not require the actual production of engines, however. Regardless, since the companies have committed to developing the capacity, the staff believes that the agreements help the overall cost-effectiveness of the proposed program, but that the effects of the agreements cannot currently be quantified.

The staff expects that manufacturers will meet the 2000 standard for Class 2 engines (above 225 cc) by the early and small-scale introduction of Federal Phase 2 engines. Since the federal Phase 2 levels are ostensibly based on the use of overhead-valve engines or similar clean and durable technology, the staff has estimated the cost based on an additional shift from some side-valve engines to overhead-valve engines. It must be noted, however, that not all engine lines need to be shifted, particularly in the higher displacement ranges; some current overhead-valve and side-valve engines are likely to meet the proposed 2000 standard with no substantive modifications.

The staff has estimated the cost to shift from side-valve to overhead-valve engines from information provided by NERA, on behalf of EMA and the Outdoor Power Equipment Institute. The staff compared the NERA analysis to the 1990 staff analysis and determined that while most of the inputs and assumptions used by NERA are consistent with those used by staff, NERA’s conclusions are not directly comparable to the cost-effectiveness figures that the ARB has used in the past. This is due primarily to the use of a different methodology and some different assumptions

than staff traditionally makes. For instance, the staff generally tries to estimate the cost to the consumer and so uses existing or projected pump prices for estimating fuel economy effects. On the other hand, NERA looked at the social cost and deducted the taxes on gasoline because the taxes are essentially returned in the form of services to society. Although the NERA approach is logical, it does not result in an estimate that can be directly compared to previous ARB cost estimates that use a different methodology. Therefore, staff did not use the NERA "Social Cost" of $0.86 per gallon; the ARB calculates cost to consumer and cost to industry, not social costs. The average current price of unleaded regular gasoline is $1.24/gallon.

The NERA analysis also differed from the staff's analysis when estimating operators' costs and savings. For example, one area of disagreement was the fuel economy improvement that would result from converting from a side-valve to an overhead-valve engine. (Note that the fuel economy savings would probably be similar for any complying technology that does not use aftertreatment, because a reduction in HC emissions means that the engine would be emitting less unburnt fuel than a Tier 1 engine. A side-valve engine that was modified to meet the standards in some way would likely result in similar savings.) Staff's assessment, based on testing performed by Southwest Research Institute [8], was that converting from a side-valve to an overhead-valve engine will reduce operator fuel use by approximately 30 percent; NERA assumed only a 15 percent reduction in fuel use. Regarding the addition of catalysts, which would not involve a change in fuel consumption, the staff and NERA's estimates are more similar.

Many other NERA assumptions differed from ARB's traditional assumptions used in the original 1990 Staff Report. These, and the differences discussed above, are summarized in Table 17, below.

[8]Air Resources Board Mail Out # 90-64, "Public Hearing to Consider Regulations Regarding the California Exhaust Emission Standards and Test Procedures for 1994 and Subsequent Model year Utility and lawn and Garden Equipment Engines," October 22, 1990.

Table 17

Comparison of NERA/ARB differences

Input	NERA	ARB
Annual Hours of Use	25	35.9
Average Life of Lawn Mower	6.5 years	7 years
Reduction in fuel use (Side-valve to Overhead-valve)	15%	30%
Weighted Horsepower	1.35	1.44
Conversion from pounds to gallons	6.14	6.18
Price of fuel per gallon	$.86 "social cost"	$1.24 "consumer cost"
Applied time value of fuel savings	Yes	No

Table 18 contains the results of staff's evaluation of the retail cost differential between a side-valve and an overhead-valve lawn mower using NERA's data but the ARB estimates for fuel cost, etc. noted above.

Table 18
Lawn Mower Retail Cost Increase

Weighted total of all lawn mowers	Residential lawn mowers only
$13.06	$23.40

The results of this updated analysis substantiates the staff's 1990 estimate of the cost differential between side-valve engines and overhead-valve engines. The average total retail cost increase for the residential lawn mower of $23.40 is slightly higher than the 1990 estimate ($21.99), but less than that 1990 amount adjusted to represent April 1997 dollars ($28.72).

An analysis of the data provided by NERA for a high volume residential lawn mower, shows that it would cost less than the average lawn mower:

Average retail cost increase per lawn mower - $23.40

Average retail cost increase per high volume residential lawn mower - $17.25

This result supports ARB's total cost analysis for the average lawn mower. It is not surprising that the additional cost for a high-volume lawn mower would be less than the average, as a high-volume manufacturer could more readily take advantage of economies of scale.

b. Tier 2 Cost Effectiveness - Staff evaluated the cost effectiveness of the proposal compared to the Federal Phase 2 levels as follows. Staff assumed that the cost to modify a lawn mower housing was representative of the cost to modify equipment throughout the entire category. Although lawn mowers are a high volume application, the usage is much less than most small-volume applications, which tend to be industrial in nature. Thus, the expected lifetime emissions benefit for lawn mowers is relatively low, which allows their use as a surrogate for the broad spectrum of engines greater than 60 cc. As the usage of the applications and the lifetime emissions benefits increase, the cost-effectiveness improves dramatically, as the generator example below shows.

Lawn Mowers less than 5 hp: Calculation of the lifetime emissions from a lawn mower indicates that a Class 1 lawn mower engine in the less than 5 hp range (typical of residential lawn mowers) meeting the federal Phase 2 standards would produce a total of 14.1 pounds of HC+NOx over the average life of the engine. Similarly, a lawn mower engine meeting the staff proposal would emit a total of 9.0 pounds of HC+NOx over the average life of the engine. Therefore, the cost effectiveness for the staff's Tier 2 proposal for lawn mowers would be calculated as follows (discrepancies are due to rounding):

Federal SOP lifetime emissions = 14.1 pounds HC+NOx
Staff Proposal Tier 2 lifetime emissions = 9.0 pounds HC+NOx
Difference = 5.0 pounds HC+NOx

Cost Effectiveness = $23.40/5.0 = $4.68 per pound HC+NOx reduced.

Lawn mowers in commercial use are used more, with a proportional increase in emissions for both scenarios, and would thus have a lower cost per pound of HC+NOx reduced.

Similarly, for small generators less than 5 hp:
Federal SOP lifetime emissions = 298.6 pounds HC+NOx
Staff Proposal Tier 2 lifetime emissions = 159.5 pounds HC+NOx
Difference = 139.2 pounds HC+NOx

Cost Effectiveness = $23.40/139.2 = $0.17 per pound HC+NOx reduced.

The cost effectiveness figures for other types of equipment would vary, but are likely to be bounded by the lawn mower and generator estimates.

For riding mowers and other engines above 225 cc (Class 2 engines), the proposed Tier 2 standard is the same as the proposed federal standard, so there would be no difference in lifetime emissions. Thus, staff did not calculate a Tier 2 cost-effectiveness figure for any engines greater than 225 cc using this methodology. Note that the earlier implementation of the Tier 2 standards would incur some cost beyond that due to the U.S. EPA phase-in. However, the investments made to comply with the proposed Tier 2 regulations could also be used to comply with the federal proposal. In fact, manufacturers that convert all products nationwide to the proposed California levels would be able to generate credits for U.S. EPA's program (based on the amount of sales in states other than California), which would further alleviate the situation.

c. Tier 3 Cost of Compliance - The staff projects that manufacturers will meet the proposed 2004 standards by utilizing Tier 2 engines equipped with catalytic converters. According to the Manufacturers of Emissions Controls Association and others, the cost to incorporate a low-efficiency catalyst (~25 percent HC+NOx conversion at the end of useful life) on an

engine with annual sales of approximately 10,000 units would be roughly $10 to manufacturers. The cost of the catalyst and substrate themselves would only be approximately $2-4 for Class 1 engines and approximately $7-$10 for Class 2 engines. The remainder of the cost is due to the need to mount the catalyst and make minor hardware changes (typically in the muffler baffles).

However, it should be noted that the cost of catalytic converters that NERA used for its own analysis are widely divergent from the estimates provided by the Manufacturers of Emissions Controls Association. The NERA analysis uses a cost to the manufacturer of $7.50 to $13.50 for a catalyst for Class 1 engines, while the Manufacturers of Emissions Controls Association indicates the cost would be from $2.69 to $4.00 for similar engines.

Using NERA data but the Manufacturers of Emissions Controls Association’s above catalyst costs, the staff estimates the total retail cost increase due to catalyst use to be approximately $20 per engine. Staff used the data to perform a new analysis of the average total cost to add a catalyst to a residential lawn mower; the result indicates that the total system cost would be from $17.69 to $19.00. For comparison, Table 19, below, also contains the results of the staff's analysis for the costs of three individual catalyst upgrades. The particular engines have not been identified to maintain confidentiality of the engine manufacturers.

Table 19

Cost of Adding a Catalyst to a Lawn Mower
Staff Evaluation of NERA

Engine	Catalyst System	Cost per unit of equipment
Staff Proposal	Catalyst reduces HC + NOx by 25% at 250 hours	$17.69-$19.00
NERA data - High volume engine 1, System 1	3-Way Catalyst reduces HC 30%, NOx 60% new	$16.30
NERA data - High volume engine 2, System 2	Catalyst reduces HC 50%, CO 70% new	$37.31
NERA data - High volume engine 2	Catalyst reduces HC + NOx by 30% new	$18.03

d. Tier 3 Cost Effectiveness - The above information was then used to calculate the cost-effectiveness of the proposed Tier 3 standards:

Lawn Mowers less than 5 hp:
Federal SOP lifetime emissions = 14.1 pounds HC+NOx
Staff Proposal Tier 3 lifetime emissions = 6.8 pounds HC+NOx
Difference = 7.3 pounds HC+NOx

Cost Effectiveness = $19.00/7.3 = $2.60 per pound HC+NOx reduced.

Incremental (Tier 2 to Tier 3)Cost Effectiveness = $19.00/2.3 = $8.26 per pound HC+NOx reduced.

Small Generators:
Federal SOP lifetime emissions = 298.6 pounds HC+NOx
Staff Proposal Tier 3 lifetime emissions = 125.4 pounds HC+NOx
Difference = 173.2 pounds HC+NOx

Cost Effectiveness = $19.00/173.2 = $0.11 per pound HC+NOx reduced.

Incremental (Tier 2 to Tier 3)Cost Effectiveness = $19.00/34.0 = $0.56 per pound HC+NOx reduced.

For Class 2 engines, the equipment cost was assumed to be the same, but the catalyst would cost, per the Manufacturers of Emissions Controls Association, from $7.63-$10.35. The total cost per Class 2 engine is therefore approximately $26.

Class 2 Lawn Mowers 5- 15 hp:
Federal SOP lifetime emissions = 10.3 pounds HC+NOx
Staff Proposal Tier 3 lifetime emissions = 7.6 pounds HC+NOx
Difference = 2.7 pounds HC+NOx

Cost Effectiveness = $26.00/2.7 = $9.63 per pound HC+NOx reduced.

Commercial Turf Care Equipment 5-15 hp:
Federal SOP lifetime emissions = 335.3 pounds HC+NOx
Staff Proposal Tier 3 lifetime emissions = 260.6 pounds HC+NOx
Difference = 74.7 pounds HC+NOx

Cost Effectiveness = $26.00/74.7 = $0.35 per pound HC+NOx reduced.

All other equipment should fall within the range of $0.11-$9.63 per pound HC+NOx reduced over the proposed federal levels, or within an incremental cost effectiveness of $0.35-9.63 per pound HC+NOx reduced beyond the staff's proposed Tier 2 level.

3. *Economic Impacts on the Economy of the State* - Although some stakeholders contend that the staff proposal would be too stringent, the proposal is actually a relaxation of the already existing requirement. In order to meet statutory requirements, the staff wrote this section to reflect the effect of the relaxation from what would otherwise occur. Note, however, that all the cost-effectiveness figures in the previous section reflect comparison with the proposed federal standards to provide an appropriate comparison between the benefits expected from each program.

a. Summary of Economic Impact on the State - Overall, most manufacturers of small off-road engines and equipment are expected to benefit from the proposed amendments. The amendments provide manufacturers with greater flexibility than the existing standards. This, in turn, results in a more cost-effective program to achieve the goals of SIP emission reductions. However, some manufacturers which have already developed compliant products may be adversely affected by the proposed amendments because they may not realize the return on their investment as soon as they have planned. Staff believes, however, that the benefits gained by the industry from the proposed amendments outweigh the slight loss of opportunity to these manufacturers. As a result, staff expects the proposed regulations to have positive impacts on California employment, business status, and competitiveness.

b. Legal Requirements - Section 11346.3 of the Government Code requires State agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include a consideration of the impact of the proposed regulation on California jobs, business expansion, elimination, or creation, and the ability of California business to compete.

Also, State agencies are required to estimate the cost or savings to any state, local agency and school district in accordance with instructions adopted by the Department of Finance. The estimate shall include any nondiscretionary cost or savings to local agencies and the cost or savings in federal funding to the state.

c. Businesses Affected - Any business which is involved in the production, distribution, service, sale, and use of small off-road engines and equipment can potentially be affected by the proposed amendments. The focus of this analysis, however, will be on manufacturers because these businesses would be directly affected by the proposed amendments. The issue of how the regulation would affect users is dealt with elsewhere in the report, specifically in the Cost Effectiveness and Issues of Controversy sections.

The ARB survey of manufacturers has identified 17 manufacturers of small off-road engines and equipment in the world that sell their products in California. Eight of these manufacturers are involved in manufacturing of handheld products such as chain saws, trimmers, brush cutters, cut-off saws, hedge trimmers, and

other two-cycle engine products. Seven manufacturers are involved in manufacturing of engines for nonhandheld products such as walk-behind and riding mowers, mulching lawn mowers, chipper/shredders, tillers and other power equipment. The remaining two are involved in manufacturing of both handheld and nonhandheld products. None of these 17 manufacturers are located in California although some have small operations in California. The affected manufacturers fall into different industry classifications. A list of the industries that we have been able to identify is provided in Table 20.

Table 20

Industries with Potentially Affected Manufacturers

SIC Code	Industry
3519	Internal Combustion Engines, NEC
3523	Farm Machinery and Equipment
3524	Lawn and Garden Equipment
3531	Construction Machinery
3561	Pumps and Pumping Equipment
3563	Air and Gas Compressors

d. Potential Business Impact - The proposed amendments are most likely to have beneficial impacts on California businesses. However, some manufacturers may be adversely affected. The amendments were developed in response to concerns raised by manufacturers of small off-road engines and equipment that the industry will be unable to achieve the second tier standards by January 1, 1999. The industry has made great efforts to meet the 1999 standards and in fact has overcome many obstacles in the development of low-emitting engines. However, staff found that most manufacturers may have difficulty complying with the required 1999 standards. The proposed amendments would relax the 1999 standards for nonhandheld compression-ignition

engines to conform with new national standards agreed upon by an SOP between the ARB, U.S. EPA and other stakeholders. The amendments would provide manufacturers with an additional year to continue their efforts in converting product lines to complying engines.

The relaxation and extension of the 1999 standards would ease the technological challenge that the industry is facing and would provide the industry with additional time to complete the development of their compliant products. This, in turn, tends to lower the compliance costs for manufacturers. However, some manufacturers that have already developed compliant products may be adversely affected by the proposed amendments. These amendments would reduce the ability of these manufacturers to benefit from their efforts and realize any income that may be generated from licensing their technology to others. Moreover, it may discourage them in their future efforts to develop complying products on time. However, staff believes that the benefits gained by the industry as a whole from the proposed amendments outweigh the slight loss of opportunity to a few manufacturers.

e. Potential Impact on Consumer Prices - The proposed amendments would postpone or reduce any potential increase in the retail prices of small off-road equipment that might have resulted from the implementation of the 1999 standards. This is because the manufacturers would have a greater amount of time to develop more cost-effective products and less stringent standards. Consumers would also benefit from the amendments because their choice of products would be greater than if the 1999 standards were retained.

Furthermore, because the proposal relaxes and delays the standards, and provides features like averaging and low-volume consideration, the proposal will allow a greater number of manufacturers and technologies to continue to supply the California market.

f. Potential Impact on Business Competitiveness - The proposed amendments are expected to have a positive impact on the ability of California businesses to compete with businesses in other states. The proposal would align much of the California program with the proposed federal program and would harmonize with the national standards for nonhandheld compression-ignition engines, thereby eliminating any competitive disadvantage for California businesses. The amendments would also provide relief

to all manufacturers of small off-road equipment regardless of their location. As previously indicated, none of these manufacturers are located in California. Some of them, however, have small operations in California.

g. Potential Impact on Employment - The proposed regulations are not expected to cause a noticeable change in California employment. The amendments may actually improve the prospect for California employment because they tend to lower the compliance costs for most California businesses. The amendments may also save some California jobs because the California market would not be abandoned by manufacturers that would not have been able to meet the 1999 standards.

h. Potential Impact on Business Creation, Elimination, or Expansion - The proposed regulations would cause no significant change in the status of California businesses. The amendments may actually benefit most manufacturers by lowering the cost of compliance. However, some manufacturers which have already developed compliant products may be adversely affected because the proposed amendments would delay the realization of return on their investment.

4. *Summary* - The cost-effectiveness figures calculated above have been compiled in the following tables for the reader's convenience. Cost-effectiveness figures typically fall in the range of $1.00 to $2.00 per pound of HC+NOx reduced. All the cost-effectiveness figures calculated herein fall below the upper limit of $11.00 per pound of HC+NOx reduced set forth in ARB's cost-effectiveness guidance.

Table 21

Cost-Effectiveness Summary
Relative to the Federal Proposal

Equipment type	Scenario	Cost per pound HC+NOx reduced beyond federal proposal
Lawn mower less than 5 hp (Residential type)	Proposed Tier 2	$4.68
Generator	Proposed Tier 2	$0.17
Class 2 lawn mower 5-15 hp	Proposed Tier 2	No benefit beyond federal proposal
Commercial Turf Care	Proposed Tier 2	No benefit beyond federal proposal
Blower	Proposed Tier 2	$0.70
Trimmer	Proposed Tier 2	$1.30
Chain saw	Proposed Tier 2	$0.48
Lawn mower less than 5 hp (Residential type)	Proposed Tier 3	$2.60
Generator	Proposed Tier 3	$0.11
Class 2 Lawn Mower 5-15 hp	Proposed Tier 3	$9.63
Commercial Turf Care	Proposed Tier 3	$0.35

Table 22

Cost-Effectiveness Summary
Incremental Proposed Tier 3 Relative to Proposed Tier 2

Equipment type	Scenario	Cost per pound HC+NOx reduced beyond Tier 2
Lawn mower	Proposed Tier 3	$8.26
Generator	Proposed Tier 3	$0.56
Class 2 Lawn Mower 5-15 hp	Proposed Tier 3	$9.63
Commercial Turf Care	Proposed Tier 3	$0.35

C. Issues of Controversy

1. *Gardeners and Landscapers* - Many members of the interested public, including professional landscapers, have been misinformed regarding the staff proposal. PPEMA issued a short letter asking the recipients to write to the Board, the Governor and their elected representatives. Included with the letter was an information sheet that contained some incorrect allegations about the staff proposal (see Attachment K). The PPEMA letter caused Ryobi to prepare its own letter to correct some of the inaccurate statements (see Attachment L). The staff believes that the information contained in this report addresses the concerns expressed by those who wrote in.

The PPEMA information sheet stated that the staff proposal would ban two-stroke engines from use in California; Komatsu Zenoah and Tanaka have both stated that they would indeed continue to offer two-stroke engines in California. The letter also indicated that the proposal would retain the 0.25 g/bhp-hr PM standard, although the staff had asked for alternatives and was, in fact, working with PPEMA members to develop an alternative to costly PM testing.

2. *Emissions Inventory* - PPEMA has expressed the opinion that the emissions inventory from the 0-60 cc (handheld) equipment is not significant enough to warrant emission regulation beyond the proposed U.S. EPA standards. PPEMA's position appears to have initially been based on the previous inventory. As noted above, the emissions inventory has been updated with better estimates of useful life and usage, and finer resolution of equipment types; many of the changes were requested in PPEMA's comments on the emissions inventory delivered in April of 1997. The improved inventory, as noted in Table 10 above, indicates the emissions difference between the federal proposal and the staff's proposal would be 24 tons per day HC+NOx. Staff considers this difference significant.

3. *Cost and Cost-effectiveness* - Briggs & Stratton and PPEMA, among other engine manufacturers, have indicated that the proposal would be too costly to implement and would not be cost-effective. Subsection B of Section IV details the staff's cost and cost-effectiveness calculations. In those calculations, staff relied on industry input and contractor's reports to determine that the proposal does indeed meet the ARB's requirements for cost effectiveness. Additionally, the staff has, where possible, taken steps to reduce the cost of complying with the overall small off-road engine program, particularly with regards to providing flexibility through emissions averaging and production line testing.

4. *Disincentive for Emissions Improvement* - Ryobi, Tanaka, the Manufacturers of Emissions Controls Association and others have expressed concern that the proposal would excessively relax the existing requirements, providing a disincentive and economic penalty to those companies that have worked in good faith to comply with the adopted regulations. Relaxation of the requirements has a negative impact on their competitiveness in the small engine market, because it damages their ability to recoup those investments. Ryobi, in particular, has made extensive investments since the existing regulations were adopted in 1990.

The staff proposal represents a reasonable compromise between the existing requirements and the U.S. EPA proposal. The staff proposal would indeed relax the existing requirements. However, it also includes measures such as the credits program and early credit generation to reward those who have been successful in reducing emissions. Staff believes that the introduction of those programs will preserve the incentive for manufacturers to

investigate new technologies rather than cling to outdated designs, while recognizing that not all attempts to develop new technologies have been successful.

5. *Equipment Availability* - PPEMA has raised concerns about equipment availability when the proposed standards are implemented. PPEMA has stated that some handheld equipment, such as chain saws and hedge trimmers, would be unable to utilize small four-stroke engines, and that therefore those types of equipment would not be available in California.

Staff believes that PPEMA is unduly concerned. As discussed in the 0-60 cc engine section, several technologies, including complying two-stroke engines, have been developed to meet the standards and electric replacements are also available for residential applications. Furthermore, the credit and averaging program would alleviate much of the problem by allowing manufacturers who cannot design complying applications to instead concentrate on other applications. Finally, much of the equipment in question (chain saws in particular) is considered to be farm (logging) or construction equipment and are preempted from state regulation (e.g., chain saws above 45 cc).

6. *Consumer Acceptance* - PPEMA has also indicated that it does not believe that consumers will accept the price increases associated with compliance to the staff proposal. As part of its cost analysis, Engine, Fuels, and Emissions Engineering did evaluate several focus groups regarding a possible cost increase due to emissions controls. Participants were positive of measures that would improve their personal and/or employee health, and even a $35.00 increase in the price of a trimmer or other unit of handheld equipment would not be a barrier to purchase (although a $50.00 increase would be). As discussed in detail above, the staff proposal is expected to increase the price of a piece of handheld equipment no more than $20.41, much below the acceptable level of $35.00.

7. *Opt-in by Other States* - EMA and some of its members have expressed concern about other states choosing to opt-in to the California program, as allowed by the Clean air Act Amendments of 1990. They argue that the threat of having to build compliant engines for a market larger than California would be infeasible. Staff has carefully evaluated this concern and has come to the conclusion that the ARB cannot carry out its mandate effectively if it places the effects of others adopting California’s programs as a primary consideration. To do so could

endanger California's ability to maintain a separate program to address the state's unique air quality problems.

Additionally, staff has seen no evidence that indicates other states would opt-in to the California program in the near-term. Staff notes that the existing Tier 1 and Tier 2 standards have been in place since 1990, and only a single state, Arizona has successfully opted-in.

D. Alternatives considered

1. *Evaluation of Alternatives Considered* - Among the alternatives the staff considered were the retention of the standards approved by the Board in 1990, total harmonization with the U.S. EPA Phase 2 programs, relaxing the standards for residential equipment, and eliminating the PM standard.

a. Retention of Tier 2 Standards - Staff rejected the retention of the original Tier 2 standards because small off-road engine technology did not follow the path that was envisioned at the time of adoption in 1990. Specifically, nonhandheld engine manufacturers have not shown the technical sophistication necessary to achieve a 3.2 g/bhp-hr HC+NOx level in most of the engines in the category. The handheld levels were determined to be more easily achieved, and staff's proposal is consistent with the original tier 2 levels.

b. Harmonization with the U.S. EPA Proposal - The small off-road engine industry strongly supported harmonization with the U.S. EPA's proposed Phase 2 standards they agreed to through Statements of Principles; however, the U.S. EPA Phase 2 levels do not achieve sufficient emissions reductions to warrant adoption in California. As noted in the inventory section above, the Phase 2 standards will cause a 6.0 tons per day shortfall from equipment preempted from the state's authority. Additionally, if California adopted the Phase 2 standards there would be a further shortfall of 14.8 tons per day from 0-60 cc equipment and 9.0 tons per day from equipment greater than 60 cc, as compared to the staff proposal. Although the U.S. EPA standards are insufficient to meet the SIP commitments, the staff has attempted to harmonize in other areas, such as certification procedures and incentives for clean engines. Much of the details must be left until the U.S. EPA program is more fully developed.

c. Relaxation of Standards for Residential Equipment - One company suggested that the ARB institute a separate, less stringent standard for residential handheld equipment. The proponents of this approach suggested that the U.S. EPA handheld SOP would provide sufficient control of residential equipment, and noted that the small emissions inventory of residential equipment and the economics of controlling low-priced residential equipment supported such a distinction. However, that argument is undermined because Ryobi's handheld four-stroke engine has been offered in a residential string trimmer for several years. Furthermore, other alternatives, such as fuel-injected two-strokes, stratified-scavenging two-strokes, and electric equipment will be available. An additional staff concern was that the preemption of construction and farm equipment below 175 hp severely limits the emissions reductions achievable from commercial equipment alone. For these reasons, staff decided not to propose a more lenient standard for residential equipment.

d. No PM standard - Although PPEMA recommended that the PM standard be removed entirely, the staff believes that a nominal standard is necessary to allow consistent inventorying efforts, and to demonstrate that the issue has been addressed definitively. However, staff's proposal does relax the PM standard to a more realistic level and allow compliance to be determined by means other than expensive PM sampling. Staff believes that its compromise addresses industry's primary concerns, which is that the existing Tier 2 PM standard is unrealistic and that PM should not be the driving pollutant for the small off-road engine regulations.

2. *Alternatives to lessen economic impact on small business* - As noted in the Additional Manufacturer Flexibility section, the staff proposal specifically includes some consideration to lessen the impact on small businesses directly affected by the regulation. The staff proposes to allow manufacturers that produce less than 500 engines annually for the California market to forego durability testing of prototype engines. In addition, the use of credits and averaging may make it possible for some small volume manufacturers to simply purchase emission reduction credits from manufacturers that can more efficiently control emissions.

3. *Conclusion* - No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective or less burdensome to affected private persons than the proposed regulation.

Attachments